Influence of Sustained and Cyclic Loading on the Bond Behavior of Pretensioned Strands

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Summary:

Within a current research project the bond behavior of pretensioned strands under sustained and cyclic loading has been analyzed. The influences on the bond anchorage as well as the load redistribution under service conditions have been determined. The results of the experimental investigations including pull-out tests, beam tests as well as tension tests are presented.

Keywords: bond anchorage, stress redistribution, cyclic loading, bond creep, strands

1. Introduction

Slender and long-spanning structural members are characteristic for current architecture and bridge design. Prestressing of concrete reduces the required depth and extends the possible span of girders and slabs. There are many publications on the structural behavior of prestressed girders. But the investigations on the bond behavior of pretensioned strands cover almost only the short-time capacity. The influence of sustained and cyclic loading was not tested systematically yet. Therefore, tests on the long-term bond behavior of pretensioned strands are ongoing at the RWTH Aachen, considering both SLS and ULS. The maximum bond capacity of strands under cyclic loading and the residual bond capacity have been tested on numerous pull-out tests as well as on prestressed girders. The bond of strands under service conditions and the load distribution is determined by tension tests, reinforced by strands as well as reinforcing bars. The test results also specify the contribution of strands on the crack control.

1.1 Bond strength of strands

Hoyer [1] described that lateral pressure appears between pretensioned steel and the encasing concrete due to the release of pretensioning forces, the so-called “Hoyer effect”. This effect influences the stress transfer from pretensioned steel to concrete predominantly in the anchorage zone. Subsequent research work on the bond anchorage of strand e.g. [2][3] as well as own work [4][5] proposed that the bond capacity of strand is composed of three main parts:

- a base value;
- a stress-dependent part;
- a slip-dependent part.

The base value of the bond can be explained by adhesion and base friction. The stress-dependent part results from additional friction due to lateral pressure between steel and concrete (Hoyer-effect). Caused by the irregular geometry of strands, strands do not fit exactly in the given duct when slip between steel and concrete occurs. Therefore, slip increases the bond stress (slip-dependent part). As the lateral pressure and the slip decreases along the transfer length l_t the bond stress is not constant (Figure 1). Further explanations on the transfer of pretensioning forces can be found in [5].

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